

## Investigating Free Fall

### Background Information

Free fall is the movement of an object toward Earth because of gravity. An object that is in free fall experiences acceleration.

**Acceleration** is the rate at which velocity changes. Acceleration occurs when there is a change in speed, change in direction, or both. During free fall, speed increases at a constant rate. But what happens when an object also moves horizontally as it falls? The curved path that results is known as projectile motion—a topic you will cover in more detail in Chapter 12. Do you think an object's horizontal motion will affect its fall?

In this investigation, you will compare the fall of two identical objects from the same height. The first object will fall straight down. The second object will be given an initial horizontal velocity at the start of its fall. You will determine how the horizontal motion of the second object affects the time it takes to fall.

### Problem

What effect does horizontal motion have on the time an object takes to fall?

### Pre-Lab Discussion

*Read the entire investigation. Then, work with a partner to answer the following questions.*

1. **Controlling Variables** Identify the manipulated, responding, and controlled variables in this investigation.

- a. Manipulated variable

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- b. Responding variable

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- c. Controlled variables

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2. **Formulating Hypotheses** State a hypothesis about the effect of horizontal motion on the time an object takes to fall.

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- 3. Predicting** Make a prediction about the result of this investigation.  
Will one object fall more quickly than the other, or will both objects hit the floor at the same time?

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- 4. Controlling Variables** Why are you told to let one object fall through a hole in the box, instead of rolling the object off the edge of the table?

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- 5. Calculating** How will you determine the average time for the five trials?

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- 6. Measuring** Why do you think you will need a stopwatch that can measure tenths of a second?

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### **Materials** *(per group)*

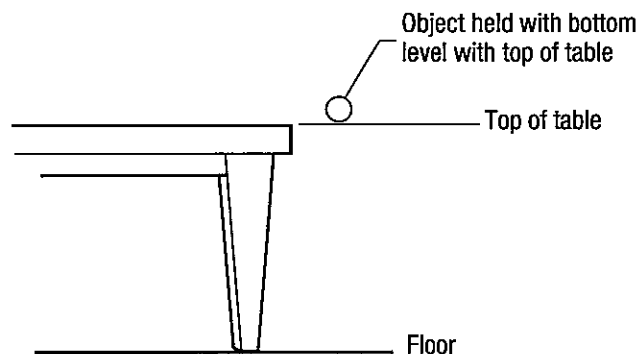
2 small spherical objects  
stopwatch (that can measure tenths of a second)  
meter stick  
masking tape

### **Safety**

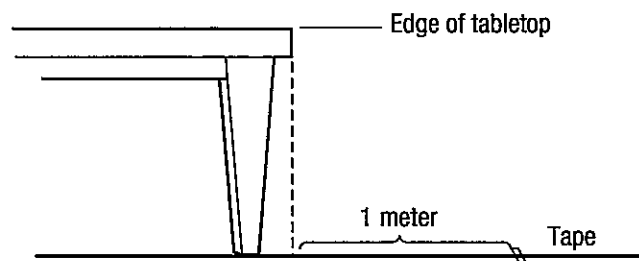
Put on safety goggles. Keep your hands and feet out of the path of falling objects. Note all safety alert symbols next to the steps in the Procedure and review the meaning of each symbol by referring to the Safety Symbols on page xiii.

**Procedure****Part A: Timing Free Fall**

1. Work with a classmate. Hold the object over the floor so that its bottom is in line with the top of the table, as shown in Figure 1. Have your classmate check that the object is being held at the correct height.

**Figure 1**

2. Position your classmate so that he or she can have a clear view of the object and the floor below. Have your classmate be prepared to start the stopwatch.
3. Count down from five and release the object when you reach zero. Have your classmate begin the stopwatch as soon as he or she sees you release the object. Your classmate will use the stopwatch to measure the time it takes the object to hit the floor. Record this time in the data table.
4. Repeat Step 3 four more times. To calculate the average time that the sphere takes to reach the floor, add all five times together, then divide the total by 5. Record this value in the data table.
5. Using the meter stick, measure and place a piece of masking tape on the floor 1 meter from the point directly under the edge of the tabletop, as shown in Figure 2.

**Figure 2**

6. Place the object to be dropped near the edge of the tabletop. Push the object off the table with just enough force so that it lands on or close to the tape. **CAUTION:** *To avoid hurting anyone, be careful not to push the object too hard.* Practice pushing the object off the table until you can make it land on or close to the tape nearly every time.
7. Repeat Step 6 one more time and have your classmate use the stopwatch to measure the time the object takes to fall to the floor. Record this time in the data table.
8. Repeat Step 7 four more times. To calculate the average time that the object takes to fall to the floor, add all five times together and then divide the total by 5. Record this value in the data table.

### Part B: Comparing Free Fall

9. Hold one of the objects above the floor and in line with the top of the table, as in Step 1. Have your classmate roll a second object toward the edge of the table. When you see the rolling object fall off the edge of the table, release the object you are holding. Watch and listen to observe whether one object hits the floor before the other.
10. Repeat Step 9 four more times. Record your observations in the space provided for results of Part B below the data table.

## Observations

DATA TABLE

Trial	Vertical Fall	Fall With Horizontal Motion
	Time (seconds)	Time (seconds)
1		
2		
3		
4		
5		
TOTAL		
Average		

### Results of Part B

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## Analysis and Conclusions

1. **Calculating** What was the average time required for the object dropped straight down to hit the floor?

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2. **Calculating** What was the average time the object with the initial horizontal velocity took to hit the floor?

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3. **Observing** In Part B, did one sphere hit the floor before the other or did both spheres land at the same time?

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4. **Evaluating and Revising** Did your data support or contradict your hypothesis? Explain your answer.

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## Go Further

The greater an object's mass, the stronger is the force of gravity on the object. Does this mean that more massive objects fall more quickly than less massive objects? Design an experiment to answer this question. Write a detailed plan for your experiment. Describe the procedures you will use and identify all the variables involved. Show your plan to your teacher. If your teacher approves, carry out your experiment.